Vol. VI. No. 8. August 15, 1909.

THE

PSYCHOLOGICAL BULLETIN

THE METHOD OF PAWLOW IN ANIMAL PSYCHOLOGY.

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About eight years ago Professor J. P. Pawlow, Director of the physiological department of the Institute of Experimental Medicine in St. Petersburg, devised and introduced into his great research laboratory an ingenious and valuable new method of investigating the physiology of the nervous system in its relations to the so-called psychic reactions of organisms. This method — now widely known as the Pawlow salivary reflex method — has been extensively employed by Pawlow and his students in St. Petersburg. Recently it has been introduced into the Physiological Institute of Berlin by Nicolai, a former student of Pawlow. It consists in the quantitative study of those modifications of the salivary reflex which are conditioned by complex receptive and elaborative processes (psychic reactions) in the central nervous system.

Inasmuch as practically all of the results of the method have been published in Russia, it has seemed to us important that a general description of the technique of the method, together with a statement of certain of the important results which it has yielded, should be published at this time in English. Our purposes in preparing this article were two: first, to present a body of facts which is of great importance to both physiologists and animal psychologists; and second, to familiarize American investigators with the salivary reflex method and hasten the time when it shall be as advantageously used in this country as it now is in Russia.

The materials for this discussion we have obtained chiefly from six papers.[1] Of these the first four are, in the main, general accounts

[1] 1. Pawlow, J. P., 'Sur la sécrétion psychique des glandes salivaires (Phé-

of the method and its results from the strikingly different points of view and interests of Pawlow and Nicolai. The papers of Selionyi and Orbeli are admirable reports of facts. At the end of this article we present a complete bibliography of the subject to 1909. We are indebted to Professor Pawlow for a number of the titles included in this list and also for a thorough revision and correction of the bibliography.

Our discussion naturally falls into four parts: (1) A general description of the method of its application, from the standpoints of Pawlow, Nicolai, and Selionyi; (2) an expository summary of the study of the auditory reactions of the dog as reported by Selionyi; (3) a similar summary of Orbeli's study of the visual reactions of the dog; and (4) a general summary of the results of the method. To give a complete account of the investigations of the St. Petersburg laboratory — for already more than forty papers have been published — would be possible only if each paper were dismissed with a sentence or two. We have preferred to consider two representative papers in some detail instead of mentioning several casually.

Description of the Salivary Reflex Method.

The salivary reflex (secretion of saliva) occurs under two strikingly different conditions: (*a*) when the mouth is stimulated by certain chemical processes (the specific stimuli for secretion); and (*b*) when the animal is stimulated by sights, sounds, odors, temperatures, touches which have been present previously in connection with stimuli of the

nomènes nerveux complexes dans le travail des glandes salivaires).' *Arch. intern. de physiol.*, T. 1, pp. 119–135, 1904.

2. Pawlow, J. P., 'The scientific investigation of the psychical faculties or processes in the higher animals' (The Huxley lecture, 1906). *Lancet*, 1906, pp. 911–915. The lecture is reported in part in *British Med. Jour.*, 1906, pp. 871–873, and in *Science*, N. S., Vol. 24, pp. 613–619, 1906. In justice to Professor Pawlow, it should be stated that *Lancet* alone gives the reader an adequate knowledge of the structure and materials of the address. It is deplorable that neither the *British Medical Journal* nor *Science* states that the lecture is published in condensed form.

3. Nicolai, G. F., 'Die physiologische Methodik zur Erforschung der Tierpsyche, ihre Möglichkeit und ihre Anwendung.' *Jour. f. Psychol. und Neurol.*, Bd. 10, S. 1–27, 1907.

4. Nicolai, G. F., 'Das Lernen der Tiere (auf Grund von Versuchen mit Pawlowscher Speichelfistel).' *Centralblatt f. Physiol.*, Bd. 22, S. 362–364, 1908.

5. Selionyi, G. P., 'Contribution to the study of the reactions of the dog to auditory stimuli.' Dissertation, St. Petersburg, 1907. Pp. 125 (in Russian).

6. Orbeli, L. A., 'Conditioned reflexes resulting from optical stimulation of the dog.' Dissertation, St. Petersburg, 1908. Pp. 111 (in Russian).

first class. The environment of the dog[1] may be said to consist of two sets of properties, the essential and non-essential. Essential, for a given reaction, are those stimulating properties of an object which regularly and definitely determine that reaction of the organism; non-essential, for the reaction in point, are those properties of an object which only in a highly variable and inconstant manner condition the reaction. The chemical property of food, whereby it acts upon the receptors of the mouth of the dog, is an 'essential' property, for it invariably causes a salivary reflex. The appearance of the same food — its lightness, color, etc. — is a 'non-essential,' for it may or may not cause the reflex. Pawlow has termed reflexes in response to 'essential' properties 'unconditioned,' and those in response to 'non-essential' properties 'conditioned.'[2]

It was Pawlow's idea that the perfectly constant and dependable 'unconditioned' salivary reflex might be used to advantage as a basis for the investigation of those complex nervous processes one of whose expressions is a 'conditioned' reflex of the same glands. Since many, if not all, changes in the nervous system gain expresssion in one way or another, through the salivary reflex, why not, Pawlow asks, investigate these processes by observing their relation to this particular reflex? That there was nothing novel in this idea is evident when we recollect that numerous reflexes have been used, by other investigators, for the study of psychic reactions. Respiration, heart-beat, and certain secretory changes have been studied, in this connection, with varying success. But what Pawlow may claim, apparently, is the discovery of that particular reflex which seems to be best adapted for the investigation of complex nervous processes.

The technique of the method we shall describe, with the help of two figures which have been re-drawn from Nicolai. The first of these figures represents a dog prepared for experiments in accordance with the method used in St. Petersburg. The second of the figures represents the modification of experimental technique which has been devised by Nicolai in Berlin.

[1] Throughout this discussion we shall deal only with the dog, in as much as it has been used for all of the Russian investigations. According to Nicolai a mixed race of hunting dogs has been used in most instances.

[2] Conditioned and unconditioned are the terms used in the only discussion of this subject by Pawlow which has appeared in English. The Russian terms, however, have as their English equivalents conditional and unconditional. But as it seems highly probable that Professor Pawlow sanctioned the terms conditioned and unconditioned, which appear in the Huxley Lecture (*Lancet*, 1906), we shall use them.

The experimental procedure is as follows. A normally active and healthy dog of vigorous salivary reaction having been selected, the duct of one of the salivary glands — the parotid for example — is exposed on the outer surface of the cheek and a salivary fistula is formed. The wound heals completely within a few days and the dog exhibits no signs of discomfort or inconvenience. Those who have used the method insist, indeed, that their animals are perfectly normal in all respects. In further preparation for the study of the salivary

FIG. 1.

reflex a small glass funnel is fastened over the opening to the duct with Mendelejeff cement. To this funnel is attached a tube which conducts the saliva to a graduate.

Three methods of measuring the quantity of saliva secreted are in use. (1) As the secretion flows from the tube into a graduate the drops are counted, and if the experimenter so desires, an additional measurement may subsequently be obtained by readings from the scale of the graduate. (2) The saliva is permitted, as Fig. 1 shows, to flow through a short tube into a graduate bottle and the amount of the secretion is then determined by reading the scale on the bottle. This method necessitates the replacing of the partially filled bottle by a clean one and the careful cleaning of the funnel between experiments. (3) A small metal canula, inserted in the duct of the gland, is connected by a heavy walled rubber tube with a small glass tube. The saliva drops from this tube upon the lever of a Marey tambour, as is shown in Fig. 2. As it falls drop by drop upon this lever a record is made

upon a smoked drum. From this record the experimenter may read the quantity of the secretion in drops and the rate of flow, *i. e.*, how many drops fell in a given interval. This graphic method of recording the salivary reaction is Nicolai's improvement on the Pawlow method as used in Russia. In addition to enabling the experimenter to obtain more detailed and accurate data concerning the reaction, it has the important advantage of permitting him to withdraw from the experiment room during the experiments. This is desirable because his presence is likely to influence the dog in unexpected and undesirable ways.

The Pawlow method lends itself readily to the investigation of many psychic reactions. In order to get clearly in mind the remaining essential points of experimental procedure we may consider its application to the study of visual discrimination of colors. A dog, which has been selected for observation and in which a salivary fistula has been created, is subjected to a course of training to establish a 'conditioned' reflex on the basis of visual stimulation. This is accomplished by showing the animal a particular color— say green —at intervals and at the same time giving it food. After numerous repetitions of this procedure the visual stimulus becomes the sign of food and induces the salivary reflex in the absence of the food. An animal so trained is ready for experiments on the discrimination of colors. If it appears that no color except green produces the 'conditioned' reflex, there is reason to believe that the dog perceives green as distinct from the other colors.

Pawlow devised and employs this method not for the study of psychic phenomena, as Nicolai proposes to do, but simply as a means of approach to the physiology of the nervous system. Of his insistence upon the objective point of view the following quotation from his Huxley lecture is excellent proof. "Up to the present time the physiology of the eye, the ear, and other superficial organs which are of importance as recipients of impressions has been regarded almost exclusively in its subjective aspect; this presented some advantages, but at the same time, of course, limited the range of inquiry. In the investigation of the conditioned stimuli in the higher animals, this limitation is got rid of and a number of important questions in this field of research can be at once examined with the aid of all the immense resources which experiments on animals place in the hands of the physiologist. . . . The investigation of the conditioned reflexes is of very great importance for the physiology of the higher parts of the central nervous system. Hitherto this department of physiology has

throughout most of its extent availed itself of ideas not its own, ideas borrowed from psychology, but now there is a possibility of its being liberated from such evil influences. The conditioned reflexes lead us to the consideration of the position of animals in nature: this is a subject of immense extent and one that must be treated objectively."[1]

Although psychology — or rather psychologists — deserves all of the criticisms which the physiologists have made, students of animal behavior and comparative psychology should not allow Pawlow's attitude to discourage them. Nor should they be slow to appreciate the immediate importance, and promise for the advancement of their science, of the Pawlow method and its results. That it can be used to advantage by animal psychologists, as well as by those physiologists for whom the psychic phenomenon is merely an unescapable nuisance, is obvious.

Already Nicholai has ably discussed the relations of the method to psychological problems. He contends, with reason, that the salivary reflex method possesses the four essential characteristics of a scientific method in psychology: (*a*) it is general, in its applicability to the study of psychic processes; (*b*) it is constant; (*c*) it permits accurate measurement; and (*d*) it is specific.

Undoubtedly the method may be applied to the study of various aspects of sensation and the mutual relations of sensations, to memory and ideation, to the formation of judgments and will acts. Its obvious limitation appears in the number of organisms with which it may be employed. Evidently it can not be used for the study of animals which lack salivary glands, and even among those animals which do possess these glands there are many which surely would not lend themselves satisfactorily to the method. It seems, therefore, as if Pawlow's method were especially important in animal psychology as a means to the intensive study of the mental life of a limited number of mammals. The dog evidently is especially well suited to the experiments.

Selionyi's Study of Auditory Reactions.

With this brief general sketch of the method and its purposes in mind we may turn to the investigation reported by Selionyi. In order, we shall state the problem, the principal points of method, and the results of his study of the auditory reactions of the dog.

The initial purpose of the work was to determine, by means of one form of the Pawlow method, how great must be the difference in the quality or the intensity of two auditory stimuli in order that they

[1] *Lancet*, 1906, p. 915.

shall produce perceivably different effects upon the auditory apparatus of the dog. The problem as it presented itself to the investigator was primarily one of the physiology of the nervous system, and secondarily one of animal psychology.

Starting with the familiar fact that sounds which have been associated with food may under certain conditions stimulate the salivary reflex, Selionyi first of all, as a necessary preliminary to his research, attempted to ascertain whether certain unusual or unfamiliar sounds, as well as those which have become familiar through their association with food, cause the secretion of saliva. He discovered that only 'familiar' sounds — those which the dog has learned to recognize as significant — have this effect as a rule.

No dogs were used for the investigation whose salivary reaction was not vigorous. An animal after having been tested for its normal reaction and prepared for the experiments by the creation of a salivary fistula, was trained until a definite 'conditioned' reflex appeared in connection with some particular sound. Repeatedly, in the training experiments, this sound was produced near the dog at the instant food was given. Sometimes the two stimuli were presented simultaneously; sometimes the sound preceded the food by five to thirty seconds. The combined action of the stimuli was permitted to continue for thirty to sixty seconds. This procedure was repeated at intervals of ten to thirty minutes, on a number of different days, until the sound, when given alone, would rapidly bring about the secretion of saliva. This usually occurred after twenty to forty repetitions. A particular sound — of definitely determined pitch, intensity, and quality — was thus rendered significant and 'familiar.' It now differed from other distinguishably different sounds in that it had its specific salivary reflex, whereas they caused no reaction.

During these training tests it is extremely important, Selionyi points out, that the experimenter make no unusual movements or otherwise produce conditions which may regularly and markedly stimulate the dog, else these irrelevant stimuli may become associated with food and spoil the result of the training experiment. In all of the experiments the experimenter has to guard against irregularities of condition. If he moves too quickly or if he holds himself too rigidly quiet, as the inexperienced worker is likely to do, the dog is disturbed and the salivary reaction modified.

The sounds whose influence was carefully observed by Selionyi were produced by an organ, by organ pipes, and by two whistles one of which (a tuning pipe) gave a number of tones of different pitch and the other a rattling sound.

A dog whose normal salivary reaction had been carefully observed and in which the habit of responding to a certain sound had been developed was placed in an apparatus similar to that of Fig. 2. The 'familiar' sound was then produced and the reaction noted. The experimenter took account of both the quantity and the quality of the saliva. A quantitative expression for the former was obtained either by counting the drops as they left the fistula or by measuring the secretion in a graduate. The quality (viscidity) was determined by

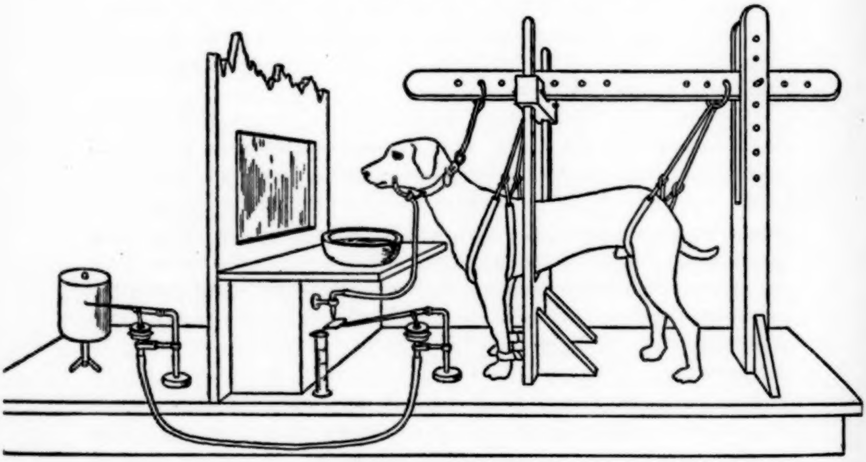

FIG. 2.

a measurement of the rate of flow through a capillary tube. Some ten minutes after the 'familiar' sound, an 'unfamiliar' sound whose influence upon the reaction the experimenter wished to discover, was given in the same way, and the reaction was again observed. After another interval, the 'familiar' sound was repeated. Thus, for the purpose of comparison, the observer obtained reactions to both kinds of stimuli in rapid succession. The experimenter noted the interval (latent period) between application of a stimulus and the appearance of the first drop of saliva, and he collected and measured the saliva which was secreted between stimulations as well as immediately after the application of each stimulus.

The sample record reproduced herewith will serve to illustrate the results obtained by this procedure.

TABLE.

EXPERIMENT 54. 'MARGARET.'

Familiar sound, A, of Tuning Pipe. Unfamiliar sound, A, of Tuning Pipe and 'Rattling' Whistle.

Time.	Sound.	Duration of Stim.	Quantity of Saliva in Drops.
4:25	Unfamiliar	1′ 40″	0
4:55	Familiar	30″	15
5:05	Familiar	20″	5
5:19	Unfamiliar	2′ 15″	0
5:29	Familiar	30″	9

In order to render a translation of Selionyi's summary of results intelligible it will be necessary to define a number of the terms which he employs.

A 'conditioned reflex' is a reaction (salivary in this case) to a stimulus which is only secondarily and indirectly a condition of the reflex. (For example, the sight of meat may produce a 'conditioned' salivary reflex.)

An 'unconditioned reflex' is a reaction to a stimulus which regularly and constantly conditions the reflex. (For example, food placed in the mouth causes an 'unconditioned' salivary reflex.)

A 'familiar' stimulus (sound, in this investigation) is one which experience has taught the animal to respond to as if it were the precursor of food. It is in fact a sound which produces a 'conditioned reflex' ordinarily.

An 'unfamiliar' stimulus is one which the animal has not been trained to respond to.

A 'fundamental reflex' is one which is caused by a 'familiar' sound.

An 'additional reflex' is one which is caused by an 'unfamiliar' sound which differs from the 'familiar' sound only in pitch.

A 'partial reflex' is one which is caused by some part of a complex 'familiar' sound. As, for example, when one tone of a 'familiar' chord causes a reflex.

In reading the summary of Selionyi's results it is important that the reader remember (1) that conditioned reflexes die out with repetition. (2)That edible subtances, when used as stimuli repeatedly, produce a constantly diminishing secretion of saliva, whereas inedible substances, when used repeatedly, produce a constantly increasing secretion. (3) That the secretion in response to edible substances increases as the interval between stimuli is lengthened, whereas the secretion to inedible substances diminishes as the interval is lengthened. Selionyi states that he made use mostly of edible substances. He did, however, at times make use of weak acid solutions as a substitute for food.

1. Separate sounds are received by the auditory apparatus of the dog as distinct stimuli even when they differ from one another by only a quarter of a tone.

2. Sounds which differ from one another only very slightly in quality are received as distinct stimuli.

3. A conditioned reflex of definite intensity is specific of (results from) a sound ('familiar') of a given pitch which has become its stimulus.

4. 'Unfamiliar' sounds which differ from the 'familiar' sound by a slight variation in pitch, produce in some dogs 'additional' reflexes which are much less intense than the reflex to the 'familiar' sound.

5. Even comparatively slight changes in the quality of 'familiar' sounds result in a diminution and disappearance of the fundamental salivary reflex.

6. Sounds which differ from one another very little in pitch (the quality and intensity remaining constant) may become the stimuli for the secretion of saliva of different degrees of viscidity: some cause the flow of liquid saliva; others, of viscid saliva.

7. The specificity of conditioned reflexes for the sounds which induce them may persist for two months.

8. Diminishing the strength of the 'familiar' sound causes the weakening or even the complete disappearance of its conditioned reflex.

9. A 'familiar' sound, which very gradually reaches such an intensity that a conditioned reflex would ordinarily result from it, fails to call forth its reflex if it was too weak at the beginning.

10. Separate components of a complex sound which conditions a 'fundamental' reflex, will produce reflexes (the so-called partial reflexes) at a certain relative intensity.

11. The intensity of partial reflexes depends upon the relative intensity of the sounds by which they are induced. The more intense the partial sound, the stronger is the partial reflex. A single tone of a familiar chord of three tones, of the same quality and intensity, produces a less intense partial reflex than do two tones of the same chord.

12. Each partial sound has its specific partial reflex just as each 'familiar' tone has its fundamental reflex.

13. The substitution of an irrelevant tone for one element of a 'familiar' chord tends to inhibit the reflex.

14. The addition of an irrelevant sound to the 'familiar' sound tends to inhibit the conditioned reflex.

15. The degree of inhibition is directly related to the intensity of the new or inhibiting sound.

16. Simultaneous stimulation by two sounds, each of which produces, when alone, the conditioned reflex (in connection with a non-conditioned reflex which is induced by the same food substance) brings about different results according to the character of the sound. In some cases the reflex which is thus produced is equal in intensity to the reflex caused by one of the two sounds; in other cases it is of considerably less intensity.

17. Under certain conditions of excitability or permanency, a conditioned reflex which has been worn out by repetitions may spontaneously reappear at the end of the interval which separated the previous repetitions.

18. The statement that a worn-out conditioned reflex may be restored by any unconditioned stimulus must be recognized as false.

19. The wearing out, by repetitions, of a fundamental reflex to a particular sound tends also to weaken the reflex to a second sound, which occurs in connection with the same non-conditioned reflex as the first sound.

20. The wearing out of an 'additional' reflex causes a slight weakening — in an acute experiment — of the fundamental reflex with which it is associated.

21. The wearing out of a fundamental reflex — in an acute experiment — causes a complete loss of the additional reflex which is associated with it.

22. The wearing out of a partial reflex — in an acute experiment — causes some weakening of the fundamental reflex.

23. The wearing out of one partial reflex causes the wearing out of another of the same intensity as the first. This phenomenon is observable in an acute as well as in a chronic experiment (at least in those cases in which the partial sounds are of the same quality).

24. By subjecting additional and partial reflexes to wear by repetition in a chronic experiment, and by simultaneously reinforcing the fundamental conditioned reflex by means of a non-conditioned reflex, it is possible to destroy completely the additional and partial reflexes while retaining the fundamental reflex in its full original intensity.

25. The independent restoration of two partial reflexes which have disappeared in a chronic experiment by reason of the repetition of one of them comes about differently. At the time when the partial reflex which was subjected to the influence of repetition has not yet reappeared the other partial reflex is fully expressed.

26. 'Unfamiliar' sounds which differ from a 'familiar' sound only very slightly in pitch, when given before the 'familiar' sound tend to inhibit its reflex.

27. A 'familiar' sound, the conditioned reflex of which has been worn out, produces an inhibitory effect upon the unworn reflex of another 'familiar' sound, when it is given simultaneously with the latter sound.

Orbeli's Study of Visual Reactions.

This investigation embraced five important phases of visual stimulation: (1) Color perception; (2) brightness perception: (3) size perception; (4) form perception; and (5) movement perception.

The method of determining the value of the salivary reaction was the same as Selionyi employed, that is, the drops of saliva were counted. The visual stimuli were presented, one at a time, upon a screen in front of the dog. Images of various colors (red, yellow, green, blue, and violet were used), intensities, sizes, and forms were projected upon this screen from the side opposite the dog by means of a lantern which focused the light upon the screen. Colored images were obtained by interposing, between the source of light and the screen, plates which acted as ray filters. The size and form of the area of the screen which was illuminated was determined by the interposition of plates whose openings varied in those respects. The movement stimuli were presented by causing the illuminated area of the screen to move in a given direction for a certain distance. The apparatus was so arranged that the experimenter, by merely squeezing a bulb, could cause a given visual stimulus to appear on the screen before the dog or to disappear.

The author's description of his method is not sufficiently precise and detailed to furnish the reader with adequate information.

In presenting Orbeli's results concerning the sense of vision in the dog, it seems fair to remark that they are not as precise and as valuable quantitatively as might have been obtained by the employment of more accurate and refined methods of stimulating the animal.

The importance of Orbeli's conclusions with reference to the visual capacities of the dog is so great that we herewith offer a translation of the summary with which his interesting paper ends.

1. A study of conditioned salivary reflexes furnishes no indication that rays of light of different wave-length are received as distinct stimuli by the eye of the dog. Conditioned salivary reflexes are always determined by changes in the intensity of light independently of its composition (quality).

2. A conditioned reflex may be produced by either increasing or decreasing the general illumination, and by the appearance of light figures on a dark background, or of dark figures on a light background.

3. Conditioned reflexes resulting from optical stimulation are essentially dependent upon the intensity of the photic stimulus.

(*a*) In many instances the importance of the intensity of the light becomes apparent quickly, for a much greater secretory effect results from a stronger stimulus.

(*b*) In the case of a certain degree of sensibility in a dog, even weak photic stimuli may produce so great an effect that more intense stimuli will not produce a greater reaction.

(*c*) Strong photic stimuli may bring about a pronounced reaction even when a weak stimulus has lost its influence by repetition.

4. The intensity of a photic stimulus depends not only upon the degree of change in light intensity, but also upon the size of the illuminated or shaded area. These two factors may compensate for one another.

5. Visual conditioned reflexes show clearly that it is characteristic of nervous tissue to respond more actively to an intermittent stimulus than to a continuous one.

6. Conditioned reflexes indicate that it is characteristic of the nervous system to enter upon a condition of excitability at the moment of the application of the stimulus, and to respond to brief single stimulations by a continued reaction. The tendency to react in this manner is especially marked, in the formation of a conditioned reflex, when the beginning of the photic stimulation coincides exactly with the beginning of the unconditioned reflex.

7. Qualitative [it is to be noted that this does not refer to color] differences in photic stimuli are determined not only by the fluctuations of the intensity of the light, but also by the specific grouping of the illuminated and the dark retinal elements (*i. e.*, by the form of objects).

(*a*) Early in the formation of a reflex the significance of form is indefinite and the reflex is determined wholly by the appearance of a light or a dark figure.

(*b*) Later the importance of the definite grouping of light and shadow (form) gradually becomes apparent. This specialization in the reflex is developed slowly.

(*c*) It is possible, in a short time, to produce a marked difference in the influence of two figures by systematically weakening the reflex to the unfamiliar figure and by reinforcing the influence of the familiar figure by the use of food.

(*d*) Rendering different the influences of a familiar and an unfamiliar figure produces conditions which greatly favor the improvement of discrimination of the familiar from the unfamiliar figure. Under these circumstances unfamiliar figures retain their independence to a certain extent.

(*e*) The different effects produced by various figures depend not upon quantitative differences (intensity of light), but upon qualitative differences, that is, upon the unequal or dissimilar grouping of simultaneously stimulated retinal elements.

8. When a difference in the effects of a familiar and an unfamiliar figure has been established, intensification of light, increase in the area of the figure, and repetition of the stimulus do not increase the effect produced by the unfamiliar figure.

9. When a difference in the effects of a familiar and an unfamiliar figure has been established, and the unfamiliar figure produces only a slight effect, its influence may be considerably increased by the introduction of irrelevant stimuli.

10. Moving objects may act upon the eye of the dog as distinct stimuli. In this case the direction of movement may determine the qualitative difference of stimulation and modify the reaction of the dog.

(*a*) In the early stages, after a conditioned reflex to movement has been established, the direction of the movement is not important and a familiar direction will have the same effect as an unfamiliar direction of movement.

(*b*) A distinct difference in the influence of movements varying in direction may be produced in a short time (by the process of wearing out the reflex to one stimulus by repetitions, and of reinforcing the other by giving food in connection with the stimulus).

11. The differences in the effects of different figures, and of movements of various direction, is apparently based upon the establishment of a conditioned inhibition. Stimulation of some regions of the retina establishes among the various groups of retinal elements the same sort of relation which obtains between the separate receptors of the entire organism.

Laws of Conditioned Reflexes and Conclusions concerning the Relative Importance of the Senses of the Dog.

The work in Pawlow's laboratory has rendered it possible to formulate a number of laws concerning the conditioned reflex. We shall mention only three of the most important of these, as examples.

Law I. A conditioned reflex can be worn out or destroyed by repetition of its conditioning stimulus or stimulus complex. Whereas at first a particular sound, sight, or odor which is indicative of food causes the secretion of several drops of saliva, after a few repetitions at short

intervals and without the presentation of food to the dog it causes no secretion. This wearing out of the conditioned reflex serves to distinguish it from the unconditioned reflex.

Law II. The destruction of a conditioned reflex by repetition does not influence other conditioned reflexes. For example, the wearing out of the conditioned reflex to the sight of a particular kind of food leaves unmodified the reflex to the odor of the food.

Law III. Irrelevant stimuli (a sudden noise, a new object in the environment, etc.), produce a depressing effect upon conditioned reflexes. In regard to the nature of their influence, they may be conveniently classed in two groups: (1) those that temporarily diminish or even suspend the activity of the conditioned reflex, but lose this retarding effect after a few repetitions; (2) those which at first tend to reduce the intensity of the reflex and finally inhibit it completely.

Many other laws of importance for investigators who wish to make use of the salivary reflex as a means of studying animal behavior are to be found in the various papers mentioned in the bibliography at the end of this article.

Nicolai, in summing up the results of the investigations concerning the senses of the dog, mentions the following interesting points:

1. Cold, which when applied to a particular spot on the skin in the dog calls forth a conditioned reflex, has a like effect when applied to another region of the skin. Localization apparently is not precise.

2. Mechanical stimuli, which when applied to a particular region of the body cause conditioned reflexes, do not have this effect when applied to other regions. In this case localization is fairly precise.

3. Warmth stimuli are distinguished by the dog from cold stimuli and both of these are distinguished from mechanical stimuli, such as tickling, scratching, rubbing.

4. The dog's hearing seems to be very well developed. To markedly different tones or noises specific salivary reflexes are given, after training. But when a sound differs only slightly, in pitch for example, from the 'familiar' tone it may cause merely a quantitative change in the reaction. If to a particular 'familiar' tone a dog reacts by the secretion of ten drops of saliva, to one a quarter of a tone higher it may respond with only eight drops, to one a half tone higher with four drops, to one a full tone higher with only one drop, while greater differences may cause no visible reaction.

5. Nicolai, like Orbeli, has failed to obtain evidences of color vision in the dog. Of the difficulties and dangers of error in the investigation of this subject the following observation is a significant indi-

cation. Nicolai discovered that a dog which was apparently able to distinguish green from red was in fact depending for its means of discrimination upon a slight difference in the action of the two different keys which were used to give the stimuli. Color had nothing to do with the reactions. For the human observer the stimuli which served to control the behavior of the dog were practically imperceptible. Evidently, visual stimuli which effect us very differently are the same for the dog; whereas certain other forms of stimulation which are for us insignificant are readily distinguished by the dog.

6. We obtain no quantitative expression of the value of the brightness, size, form, or movement perception from the papers on the visual reactions of the dog, but the presence of these several kinds of visual ability is demonstrated.

7. Two stimuli may be compared as to intensity (stimulating value) by comparison of the amounts of saliva which they cause to be secreted.

8. Comparison of stimuli of different sense modes indicates that the following is the order of diminishing importance for the dog: Smell, hearing, cutaneous sense (mechanical stimuli), vision, temperature senses. The dog is preëminently a nose-animal. Indeed, so acute is the sense of smell that it has thus far proved impossible to study it to advantage. Our color vision may enable us to teach the dog to distinguish colors, but he is in a position to give us instruction in smelling!

Finally we may be permitted to quote from Nicolai his conclusions concerning the relation of the Pawlow method to animal psychology.

"The Pawlow salivary reflex is a relatively complicated process which is connected only indirectly with the exciting stimulus and for the occurrence of which the idea of eating is always necessary."

"Pawlow's salivary reflex method gives us a better explanation of the manner in which a dog learns spontaneously [than do most other methods], but it remains to be shown how far the learning can be carried. In the solving of related questions, the method does not seem to be superior to Kalischer's training method, and the latter is much the more convenient."

"One can show experimentally that a dog learns by subsuming certain new ideas under general ideas which he has already acquired in the course of the experiment."[1]

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PSYCHOLOGICAL LITERATURE.

LITERATURE OF THE PAST YEAR ON THE BEHAVIOR OF LOWER ORGANISMS.

Protozoa.

It is well known that the protozoa take in various sorts of indigestible substances in the process of feeding and it is generally assumed that they exercise no choice whatever in this process. The observations of Balbiani on *Didinium* (1873) contradicting this assumption have been shown to be erroneous, and the validity of those of Hodge and Aikins on *Vorticella* (1895) and those of Metalnikow on *Paramecium* (1907) leading to the same conclusion have been seriously questioned.

In view of these facts we welcome the recent thorough work of Schaeffer[1] on this subject, reported at the last meeting of the American Society of Zoölogists at Baltimore.

Schaeffer allowed a mixture containing *Euglena viridis*, *Phacus triqueter*, *Trachelomonas volvocina*, potato starch grains, particles of sand and other small bits of substance, to fall from a capillary pipette onto the disk of an attached *Stentor* and found that the organisms were invariably swallowed, while the starch, sand and débris were rejected. He also found that when the organisms became nearly satiated they consistently rejected *Trachelomonas* while they still took *Euglena*, and is of the opinion that under certain conditions some individuals of *Euglena* are selected and others rejected. *Euglena* killed by heating, or by means of various chemicals, if thoroughly washed, were taken quite as readily as living specimens. This led the author to conclude that selection is due to tactile rather than to chemical stimuli.

In studying the behavior of *Didinium* Mast[2] also found a sort of food selection. In the presence of various organisms these hunter ciliates were found to attack various species of *Paramecium*, *Colpoda*, *Colpidium*, *Vorticella*, *Frontonia* and *Nassula*, but not *Stentor*, *Euglena*, *Spirostomum*, *Oxytricha* and several others.

[1] Schaeffer, Asa, 'Selection of Food in *Stentor cœruleus*'; abstract, *Science*, N. S., Vol. 29, p. 425.

[2] Mast. S. O., 'The Reactions of *Didinium nasutum* (Stein) with Special Reference to the Feeding Habits and the Function of Trichocysts,' *Biol. Bull.*, Vol. 16, pp. 91–118.

Didinium swims about rapidly and consequently comes in contact with other organisms and objects that may be present. Under certain conditions a rod-like structure known as the seizing-organ, becomes attached to the organisms with which they come in contact. The seizing-organ then travels to the posterior end of the *Didinium* and the prey is swallowed. "The apparent choice of food is due to the fact that the seizing organ will adhere to the surface of some organisms and not to that of others. The *Didinia* come in contact with all sorts of objects in their random swimming and attempt to swallow all of those to which the seizing organ will adhere" (p. 118). The adhesion of the seizing organ to the surface of some organisms and not to that of others may however be due to chemical or tactile stimuli. The seizing organ does not adhere every time the *Didinia* come in contact with organisms upon which they feed; they seem to have some method of controlling this process.

Didinia feed primarily on *Paramecia*. They can swallow organisms ten times their size and consume several a day. When the *Paramecia* are attacked they throw out masses of trichocysts which frequently force the enemy back and break the connection, so that the prey escapes. This demonstrates a protective function of the trichocysts.

"One cannot work long with this unicellular form without being deeply impressed with the complexity of its structure as well as with its unique habits. The differentiation of the seizing organ with its highly specialized function is remarkable in an organism consisting of a single cell" (p. 111).

Echinoderms.

Two contributions to the behavior of the echinoderms have appeared during the year, one by Pearse dealing with the general behavior of the holothurian *Thyone*, the other by Bohn dealing with the reactions to light in starfishes and ophiuroids.

Pearse[1] gives a very interesting account of the various activities of *Thyone*— locomotion, burrowing, feeding, respiration and response to various stimuli. He finds that while these organisms respond very definitely by contraction, when subjected to slight tactile stimuli or when the light intensity is slightly decreased, they soon become acclimated to such conditions and no longer respond.

"Perhaps the most interesting point which is brought out in the study of *Thyone's* behavior is the fact that, although the symmetry is

[1] Pearse, A. S., 'Observations on the Behavior of the Holothurian, *Thyone briarens* (Leseur),' *Biol. Bull.*, Vol. 15, pp. 259–288.

so strikingly bilateral, the locomotion is carried on with the same lack of orientation which is so characteristic of other groups of echinoderms" (p. 287). This feature in the behavior of *Thyone* is clearly brought out in its reactions to light. It moves from the surface most highly illuminated no matter which part of the animal is exposed. Thus, it may move with either end or any portion of the sides ahead.

Bohn[1] first describes in considerable detail the reactions to light and various other stimuli in *Asterias rubens* collected in various places, *e. g.*, under rocks, on sand bottom, among sea weeds, etc., and then briefly considers the reactions of seven other related forms in a comparative way.

Many of the results and conclusions presented are interesting and suggestive, but the evidence supporting them is frequently far from convincing owing largely to the methods employed. The author in all his work justly emphasizes the importance of making observations under natural conditions. In studying the reactions to light, *e. g.*, the observations were made on starfish in tide-pools where the shadows of rocks produced regions of different light intensity, or in aquaria exposed to light from a window with black and white screens variously arranged to regulate the intensity.

Such methods answer fairly well for rough qualitative work, but when they lead to conclusions such as the following one naturally begins to question the validity of the conclusions:

> Souvent les phénomènes se succédaient avec la même précision que les phénomènes astronomiques ; dans maintes circonstances c'est avec une certitude absolue que j'ai pu prédire ce qui allait se passer (p. 12).
>
> Les diverses impulsions déterminées par les agents du milieu extérieur (lumière, gravitation . . . , excitants mécaniques) se combinent dans le système nerveux du disque, et il en résulte des mouvements, qu'après l'analyse que j'ai faite on peut prévoir à l'avance ; l'animal, dans des conditions déterminées, suit infailliblement une certaine trajectoire : il n'est pas plus maître de modifier sa marche qu'un astre qui gravite autour d'un autre dans l'espace ; il ne peut résister aux diverses impulsions ayant leur point de départ dans les agents externes (p. 59).

Something can undoubtedly be predicted regarding the movements of echinoderms under certain conditions. No one would be bold enough to deny that some reactions can be predicted even in organisms far more complicated than echinoderms. It is not difficult to predict the general movement of a human being when a revolver is thrust into his face by a figure behind a bull's-eye. The question is, how accurately and how extensively can the movements be predicted?

[1] Bohn, G., 'Introduction à la Psychologie des Animaux à Symétrie Rayonnée, II. Les Essais et Erreur schez les Étoiles de mer et les Ophiures,' *Bull. Inst. Génér. Psychol.*, VIII., pp. 1–86.

In spite of the author's statement quoted above regarding external stimuli he admits the importance of internal factors, but insists that there are no psychic phenomena. "Il est nécessaire toutefois de faire remarquer que les impulsions dépendent de certains facteurs internes, et non pas seulement de facteurs externes: il y a lieu de tenir compte des états physiologiques. . . . Mais il n'y a là dedans rien de psychique" (p. 60). We judge internal factors, the physiological states, in an organism largely by its variation in response to given external stimuli. There are as yet few other criteria. How then is it possible to predict movements which depend upon physiological states while these states are known almost entirely through such movements? And since we do not know of what the internal factors consist, is it not precisely as unscientific to say that there are no psychic phenomena involved as that there are? One is inclined to think that if the author had exercised more care in controlling his stimulating agents he would not have been so positive in his assertions that he had analyzed the reactions to such a degree that the movements can now be predicted.

Whether or not the starfish is able to modify its course depends upon what one considers the starfish to be. If the starfish is assumed to consist not only of the material composing it, but also of the chemical changes taking place in this material, it of course modifies its reactions, since the reactions according to the author depend upon internal changes, physiological states. What regulates the internal changes is a question concerning which little is as yet known, and any dogmatic statement regarding it as a whole is at present without foundation.

In view of these facts a bare statement comparing the movements of living organisms with those of planets, as in the quotation above, seems to be far fetched, since it is evident that the movements of the latter are independent of internal changes as long as the mass remains constant, whereas those of the former are not.

The author concludes that these organisms respond to constant intensity by orientation, 'tropisme,' and to a change of intensity by rotation, 'sensibilité différentielle'—"Avec Loeb, j'ai distingué nettement chaque *tropisme* de la sensibilité différentielle correspondante, l'un est fonction de *i*, l'autre de *di/dt*" (p. 56). Let us consider these two responses, (1) sensibilité différentielle and (2) tropisme.

1. The author says (p. 6), that it is to Loeb that we owe the idea of sensibilité différentielle, Unterschiedsempfindlichkeit, reaction to change of intensity of stimulus. Loeb, however, as far as I know, never claimed to have originated this idea. It formed the foundation

of the 'preference method' so extensively used by Bert, Graber, Lubbock, Romanes and others, years before Loeb began his work in this line. Naegeli (1860), Strasburger (1878), Stahl (1880), and Engelmann (1882) had also recorded specific reactions to sudden changes of intensity. Darwin (1880) states this idea clearly as follows: "We believe that this case," referring to an experiment of Wiesner, "as well as our own, may be explained by the excitement from light being due not so much to its actual amount, as to the difference in amount from that previously received" (p. 566). Ryder described the reaction of one of the serpulids to decrease of intensity in 1883, ten years before Loeb's paper referring to similar reactions appeared. What Loeb claims regarding the effect of change of intensity of the stimulus is that it differs from the 'tropisms.' This he pointed out in 1893 and several times since. As a matter of fact in his earlier papers he strenuously opposed the idea that difference or change of intensity is of importance in behavior.

I have found no organisms that fail to respond to changes of light intensity provided that they respond to light at all, and I have tested representative specimens ranging from the lowest to the highest. The fact then that the author finds a definite response to change of intensity in echinoderms is to be expected. The law however which he has formulated regarding the relation between these reactions and the so-called tropisms needs attention. This law is variously stated in different papers; the following is perhaps the clearest statement:

> Chez les animaux qui présentent un phototropisme positif, toute variation négative (diminution) de l'éclairement, portant sur toute l'étendue du champ lumineux, tend à produire immédiatement ou après un arrêt plus ou moins prolongé, le changement de signe du phototropisme; chez les animaux qui présentent un phototropisme négatif, c'est une variation positive (augmentation) qui a le même effet; la tendance provoquée par l'éclairement, dans l'un et l'autre cas, peut se réaliser complètement ou incomplètement (une seule rotation de 180 degrés, rotation successives, oscillations régulières ou irrégulières). Il applique non seulement aux animaux tubicoles et fixés, mais encore à ceux en train de nager, de marcher, de ramper. (Bohn, G., 'A propos de l'excitabilité par la lumière,' *Compt. rend. Soc. Biol.*, Vol. 63, p. 655.)

By positive phototropism, I judge that Bohn means that the animals go toward the source of light, and by negative that they go from it. According to his law, then, a decrease of intensity tends to make animals which go toward the light turn and go in the opposite direction, *i. e.*, it tends to make positive animals negative; and an increase tends to make negative animals positive. Strasburger as early as 1878 found precisely the opposite to be true in case of swarm-spores.

He demonstrated conclusively that if the light intensity is sufficiently increased when these organisms are positive, they become negative. I have since found the same to be true for Volvox, Euglena, Chlamydomonas, Trachelomonas, and several other forms. A reduction of intensity does produce a definite reaction, a shock movement, in these forms in the positive state, and such reactions regulate orientation, but they have nothing to do with the sign of orientation. The organisms remain positive and under certain conditions become even more strongly positive. On the other hand an increase of intensity, whether rapid or slow, produces no definite immediate response, no shock movement, in positive animals, but if long enough continued and sufficiently great it causes them to become negative. The change in the sign of reaction is probably due to some chemical change in the organism which is dependent upon the absolute intensity of light, not upon the time rate of change of intensity.

2. **Tropisms.** The author states that when the animals are exposed in a field of uniform light intensity they move either toward or away from the source of light, or they may take a position such that the most sensitive parts of the body are shaded. These reactions are considered to be the result of constant intensity and are therefore called 'tropisms.'

It is evident that, under the conditions of illumination referred to above, certain parts of the animals are in the shadows cast by other parts, and the movements of the animals, if they are not directly toward or from the source of stimulation, cause change in position of the shadows and consequently changes of light intensity on the organism. Is it not possible that the reactions of the star-fish in a field of uniform illumination are regulated by such differences and changes of intensity just as they are in unicellular organisms, *Euglena Stentor*, etc., under similar conditions? If it proves to be true that they are regulated thus, the fundamental distinction between 'tropisme' and 'sensibilité différentielle' as defined by Bohn falls to the ground. Light does undoubtedly affect the movement of organisms without change of intensity, but I have yet to find a single instance where it has been *demonstrated* that it regulates the process of orientation in organisms without image-forming eyes.

Trial and Error. — Bohn emphasizes again and again that the reactions of starfish and ophiuroids and various other forms are not in accord with the theory of 'Trial and Error' as defined by Jennings, and appears to consider this fatal to the theory. Bohn's conclusions are based largely upon the fact that the organisms studied orient directly

to light and respond in a fixed way to changes of intensity. He is astonished that Jennings has not referred to the reactions of starfish to support his theory. "Jennings aurait certainement dit qu'il y a là des 'essais successifs' dans diverses directions, et, comme dans bien d'autres cas, il aurait été victime d'une illusion" (p. 6). It is interesting to note that Jennings has made an extensive study of the reactions of a starfish, the results of which appeared at nearly the same time that the paper under consideration was published, and that, contrary to Bohn's prediction, he does not explain orientation by the application of the trial and error theory. Jennings has repeatedly stated that direct orientation, differential response to localized stimulation, is not in opposition to the 'trial and error theory' as applied in his study of reactions. He says in his book on *Behavior on Lower Organisms* (p. 307), "Reactions [which] show a definite relation to the localization of the stimulus . . . include perhaps the greater number of the directed movements of organisms."

Bohn finds that young starfishes orient more directly than older ones and offers this as an argument against the 'trial and error theory.' I fail to see the force of his argument. Had he found that the very first movements of embryos are more direct with reference to the localization of the stimulus than later movements, there might possibly be some ground for his argument. The smallest starfishes he mentions were however several centimeters in diameter. The fact that these orient more directly than older ones is as far as I can see not in opposition to Jennings' views as stated in his book.

The bare sweeping statement that "those who criticise the theory of tropisms show a double ignorance, (1) ignorance of the facts as they are; (2) ignorance of the ideas of J. Loeb" (p. 77), has in my opinion no value in science. If the author really thinks the critics of the 'tropism theory' ignorant of the ideas of Loeb and the facts, would it not be well for him to present the evidence which has led him to think thus?

The paper closes with a bibliography consisting of sixty-five titles, fifty-five of which bear the name of Bohn.

Crustacea.

A number of different crabs are known to fasten seaweeds and other objects to their carapace. A paper by Minkiewicz dealing with this phenomenon was reviewed in this Bulletin a year ago. In the review it was pointed out that the author had found that the objects selected by the crabs harmonized in color with that of the environment,

and it was maintained that he had demonstrated 'color vision' in these forms. We now have three additional short papers by the same author on related phenomena in other forms.

1. According to Minkiewicz[1] the color of the crab *Hippolyte varians* changes so as to harmonize with the background. The color changes are brought about by the interaction of three pigments, red, yellow and blue, found in the cells of the carapace. The blue pigment is permanently diffused throughout the cells, the red and yellow may contract or expand. On a red background, *e. g.*, the blue disintegrates and the red expands. On a green background the yellow expands but the blue remains, making the carapace green. In specimens with the eyes removed the blue acts normally but the red and yellow no longer expand, showing that the color changes are regulated by the direct action of light on the blue pigment, and the indirect action through the nervous system on the red and yellow.

The author considers the phenomena concerned in these color changes fundamentally identical with those concerned in disguisement referred to above. In the former exposed to red light, *e. g.*, the red pigment becomes positive and spreads out, in the latter under similar conditions the entire animal becomes positive to red and selects red objects to fasten to its carapace. In both cases the reaction is brought about through the retino-neural mechanism.

The fact that the color of *Hippolyte* changes so as to harmonize with violet, yellow and other colors which the animals do not experience in their natural environment, and the fact that the animal becomes blue in darkness, lead the author to conclude that these phenomena are of primary origin and are not acquired by natural selection.

It is impossible to judge as to the probable accuracy of the observations since practically nothing is given regarding methods.

The remaining two brief papers[2] deal with the reactions to different colors of *Pagurus*, a hermit crab. The author illuminated the two halves of an aquarium with light of different colors and placed the animals so that the two eyes were exposed to light of different colors and found that the creatures turned toward the color indicated by the arrows below, *i. e.*, in case of black and red in the aquarium

[1] Minkiewicz, R., 'Étude expérimentale du synchromatisme de *Hippolyte varians* Leach.' Ext. d. *Bull. d. l'Acad. d. Sci. d. Cracovie*, Nov., 1908, pp. 918–929.

[2] Minkiewicz, R., 'Sur le chlorotropisme normal des *Pagures*.' Nov., 1908. 'L'apparition rhythmique et les stades de passage de l'inversion expérimentale du chlorotropisme des *Pagures*.' Dec., 1908. *Compt. Rend. Acad. Sci.*

they went toward the red; in case of red and yellow, toward the yellow, etc., as indicated below.

black → red → yellow → blue → violet → green → white

If the crabs are kept in a jar and exposed to their own excreta for some time their reaction to colors gradually changes as follows:

Normal: red → blue → green
red → green → blue
green → red → blue
green → blue → red.

It is pointed out that these reactions cannot be due to intensity difference, since the light in the yellow is more intense than that in any other color.

These reactions appear to *demonstrate* 'color vision' in *Pagurus*, regardless of what philosophic attitude one may have toward an ultimate explanation of them.

Cowles[1] arrives at some interesting conclusions in his extensive study on the general behavior of the crab *Ocypoda*. He presents strong evidence showing that these creatures make use of the sense of smell and sight in locating food, that the tactile sense is well developed, that they "have memory, are able to profit by experience, and can form habits," but that they do not hear. He finds no evidence indicating that these animals distinguish colors, and is of the opinion that they do not see details in objects. Sight consists largely in distinguishing variation in brightness rather than in form.

The observations and experiments were nearly all made on animals in their natural environment. Those leading to the conclusion that the crabs have associative memory are especially worthy of mention.

Although these organisms live on the land it is necessary that they keep their gills moist. This they do by taking a definite position on the beach at a point such that the waves just reach them. The author found that in an enclosure containing a glass dish full of water the animals soon learned to take a similar position when the locomotor appendages came in contact with the glass and water; and later it was found that the same reaction was given when the glass was touched even if the dish was empty.

Holmes[2] in his study of the reactions of the fiddler crab to light has presented some interesting ideas regarding the question of orientation.

[1] Cowles, R. P., 'I., Habits, Reactions, and Associations in *Ocypoda arenaria*,' Pub. 103, Car. Inst. of Wash., 1908, pp. 1-41.

[2] Holmes, S. J. 'Phototaxis in Fiddler Crabs and Its Relation to Theories of Orientation,' *Journ. of Comp. Neurol. and Psychol.*, Vol. 18, pp. 493-497.

He found that this animal, especially when first brought into the laboratory, goes actively toward a source of light, but owing to its peculiar mode of locomotion it travels toward the light with one side ahead. The theories of Verworn, Loeb and Bohn demanding equal illumination of the photosensitive structures on opposite sides when organisms are oriented, are of course not applicable to this form.

Holmes concludes from this study, together with that on *Ranatra*, "that light is followed very much as an animal pursues any other object of interest, such as prey, or its mate, and until we can give a physiological explanation of these phenomena we are not in a position to give a satisfactory explanation of orientation to the direction of the rays of light." This conclusion, of course, applies only to animals with image-forming eyes.

Insects.

After a careful study of the reactions of *Drosophila* strongly stimulated by light, temperature, or irritating chemical vapors which cause various uncoördinated motor reactions, Carpenter[1] concluded that these reactions "may be regarded as an instance of trial and error behavior." "The escape of the insect from the region of stimulation appears to depend on chance."

He found that insects with one eye destroyed and consequently unsymmetrically stimulated, "crept in a fairly direct path toward the light." This result is similar to that obtained by Holmes with *Ranatra* and by Rádl with *Musca*. It shows that symmetrical stimulation is not necessary in orientation in these forms and opposes the tropism theory as defined by Loeb and Verworn and recently strongly advocated by Bohn.

Stockard[2] finds that the behavior as well as the structure of the 'Walking-stick' *Aplopus mayeri* is admirably adapted for protection against its enemies. These creatures remain perfectly quiet during long periods in daylight and move about at night. When touched they fall and cling to lower branches where they become perfectly quiet and concealed. When they move they swing from side to side slowly like a twig swayed by a gentle breeze. The different individuals are usually found on twigs which harmonize with them in color, — the males, which are greenish, among the leaves, the large dark-

[1] Carpenter, F. W., 'Some Reactions of *Drosophila*, with Special Reference to Convulsive Reflexes,' *Journ. of Comp. Neurol. and Psychol.*, Vol. 18, pp. 485-491.

[2] Stockard, C. R., 'II., Habits, Reactions, and Mating Instincts of the "Walking-stick" *Aplopus Mayeri*,' Pub. 103, Car. Inst. of Wash., 1908, pp. 43-59.

brown females on large dark stems, and the light-gray specimens on lighter colored stems.

These creatures swing the antennæ about much, apparently feeling their way as they move from place to place. If the antennæ are amputated the fore legs are used as feelers, and if these are removed and the specimens are blinded, either the right or the left leg of the second pair is brought into service as a feeler. This is a remarkable reaction in view of the fact that in normal specimens the legs are never used in this way.

The author found that males copulate normally with the posterior end of a female fastened to a stick. Kellogg (1906) obtained similar results in his study on 'Silkworm Moth Reflexes.' Stockard concludes (p. 59) that "such an experiment makes it evident that a courtship or psychical response is not essential between the two sexes in mating." While these experiments indicate that the process of copulation is largely reflex, I am unable to see that they have any bearing on the question of psychical phenomena.

Lower Vertebrates.

Coghill [1] removed *Diemyctylus* embryos from the eggs before there was any indication of response and studied the development of the reactions to tactile stimuli somewhat as Paton (1907) had done for fish embryos. The results of this study are interesting and suggestive, but they do not appear to warrant any very definite conclusions.

Parker [2] presents a thorough study of the reactions of *Amphioxus* to various stimuli, and concludes that these animals possess in potentia at least the sense organs of the vertebrates. The author suggests that the eye-cups in the nerve-tube, which are photoreceptors in *Amphioxus*, "represent the elements from which the rod- and cone-cells of the lateral eyes of vertebrates have been derived. The rod- and cone-cells of the vertebrate retina are inverted, not because they have retained a morphological position dependent upon an external origin, but because of their orientation acquired as effective eye-cups in the nerve-tube of a primitive vertebrate."

In his study of warning coloration Reighard [3] deals with much

[1] Coghill, G. E., 'The Reactions to Tactile Stimuli and the Development of the Swimming Movements in Embryos of *Diemyctylus torosus* Eschsholtz,' *Journ. of Comp. Neurol. and Psychol.*, Vol. 19, pp. 83–105.

[2] Parker, G. H., 'The Sensory Reactions of *Amphioxus*,' *Proc. Amer. Acad. Arts and Sci.*, Vol. 43, pp. 415–455.

[3] Reighard, J., 'IX., An Experimental Field-Study of Warning Coloration in Coral-Reef Fishes,' Pub. 103, Car. Inst. of Wash., 1908, pp. 257–325.

which is of interest to comparative psychologists. His object in this study was to explain the origin of the variegated patterns in the strikingly colored fish found among the coral-reefs at the Tortugas. He began this investigation by making a thorough study of the feeding habits of the gray snapper, a piscivorous fish which one would expect to feed on the colored fish in the reefs. It is this study which is of particular interest to psychologists.

It was found that the gray snappers take atherinas (a small fish used in the feeding experiments) killed in formalin and stained any color, but that they do not take these fish if cassiopea tentacles are fastened to them. In the presence of a mixture of red atherinas with tentacles and blue without, the snappers soon learned to avoid the red; and after some time they rejected the red specimens, some of which were lighter and some darker than the blue, even if no tentacles were fastened to them. This power of discrimination was still found in snappers twenty days after they had learned to reject the red atherinas.

These experiments, and many others, all of which show ingenuity in method, led to the following conclusions regarding the gray snapper:

1. Gray snapper discriminates colors, as was demonstrated for creek chubs by Washburn and Bentley.
2. Gray snapper discriminates form.
3. It forms associations and has memory.
4. It learns rapidly. To quote the author: "The gray snapper discriminates with great rapidity and delicacy between the various possible food elements of its environment, which are not conspicuously different from each other."

Some have objected to the conclusion concerning color-vision on the ground that the colors used were not pure. The red contained some yellow and green, while the blue contained some green. I can not understand the force of this argument. The experimental results seem to me to prove conclusively that the fish discriminates between light consisting largely of the longer waves and that consisting largely of the shorter, regardless of intensity.[1] If this be true it appears to justify the conclusions stated. Of course no one would be bold enough to conclude that the vision is or is not like that in man, since there is no way of determining even whether or not the sensation of a given color is the same in two human beings.

Regarding the question of Warning Coloration, the author concludes

[1] This proof rests primarily upon the fact that grey snappers trained to avoid red atherinas in the presence of blue atherinas do so no matter if the red are lighter or darker than the blue.

that the fishes in the reefs are conspicuous because the reefs have afforded them protection against their enemy to such an extent that natural selection has not operated to eliminate this characteristic. He offers a substitute for the theory of warning coloration known as '*immunity coloration.*'

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RECENT RESEARCHES ON THE BEHAVIOR OF THE HIGHER INVERTEBRATES.

I. TROPISMS.

After studying *Vanessa cardui*, *V. urticæ*, *V. io*, and *Satyrus janira*, Bohn[1] decides that the movements of these butterflies are the result of a triple orientation to the air, sun and gravitation. He found that, in pillaging flowers, the lines described by the head of each butterfly were arcs of circles arranged in three principal directions: (1) Rarely the body retains constantly the same direction and the head describes an arc on a meridian; (2) more often the body is displaced parallel to the light and the head describes an arc of a circle situated in a vertical plane; (3) usually the body is displaced, successively, on several azimuths and the head describes a circumference situated in a horizontal plane or in a plane inclined at various degrees to the horizon. In this last case, the body adjusts itself constantly to the wind and light. All of these butterflies are positively anemotropic and negatively phototropic, but the degree varies with different species, and the force with which the wings are moved is a function of the intensity of the illumination of the eyes. Hence, when the wind is blowing at right angles to the rays of the sun, the butterflies sidle across the direction of the wind. No investigation was made of the mechanism that brings about this orientation.

II. VISION.

Alex. Petrunkevitch's recent paper[2] on the sight of spiders is a morphological study yielding psychological results. By measuring the angles which the axes of the eyes make with the three reference planes of the body and with each other, by measuring the size of the eyes, by removing the eyes and mounting them under the microscope in

[1] Bohn, G., 'Observations sur les papillons du rivage de le mer,' *Bull. Inst. Gén. Psy.*, Vol. 6, pp. 285-300.

[2] Alex. Petrunkevitch, 'The Sense of Sight in Spiders,' *Jour. of Ex. Zool.*, Vol. V., 1907, pp. 275-310.

such a manner that images may be obtained through them, the author arrives at these valuable conclusions: (1) No pair of eyes is focused upon a common point; but the axes of the eight eyes are so arranged as to form divergent angles with each other. (2) The axes of the same eyes in different spiders do not lie in the same direction, but form, with the three planes of the body, angles differing considerably from each other but fixed for each species. (3) When the spiderling leaves the cocoon, the eye-axes have become fixed in the position which they will occupy during the whole life of the growing and mature spider. (4) The cephalothorax grows more rapidly than the eye group, so that the latter occupies, with each successive moulting, a relatively smaller part of the cephalothorax. (5) The larger the spider's eye, the sharper the vision or power of distinction. (6) The four pairs of eyes form four pairs of images differing in size; the larger eyes forming the larger images. (8) The more rods covered by the image, the more detail can be perceived by the eye. The spider perceives much less detail than man. (8) In all probability, the eyes form distinct images; because, first, the distortion in each eye is in an opposite sense to that of the other eye of the pair; second, the retina is not a plane, but a complicated form differing in different eyes and in different species.

Petrunkevitch thinks that spiders have color vision, but gives no new data to support the statement. In the lobster, according to Hadley,[1] reactions to colored lights are really reactions to different intensities of light.

III. Maternal Instincts.

Lécaillon[2] makes the following interesting contribution to our knowledge of the maternal instincts of spiders: When the cocoon becomes crowded, the female cuts a few silken strands with her jaws, thus allowing the cocoon to stretch and give more room to the inmates. This manipulation also admits more air. This attention on the part of the mother spider is just as essential and important as the incubation of eggs by birds or the suckling of babes by mammals. The young could not leave the cocoon unless aided by the female.

In a comparative study of American and European ants, Wheeler[3]

[1] Hadley, P. B., 'The Behavior of the Larval and Adolescent Stages of the American Lobster (*Homarus americanus*),' *Jour. of Comp. Neur. and Psy.*, Vol. XVIII., 1908, pp. 199-301.

[2] Lécaillon, A., "Nature et importance des 'soins' que certaines femelles donnent à leur progéniture." *Compt. Rend. Soc. Biol.*, t. LXIII., 1907, p. 668.

[3] Wheeler, W. M., 'Comparative Ethology of the European and North American Ants,' *Jour. f. Psy. u. Neur.*, Bd. XIII., 1908, S. 404-435.

discusses the nidification habits of ants. He agrees with Forel that the mounds are built for the purpose of securing more heat for the incubation of the young.

IV. Social Instincts.

Comstock's paper on the wall-bee[1] is of interest to the archæologist only. The bulk of Newell's first paper[2] on the 'New Orleans Ant,' consists of matter of economic rather than of psychologic value; however, it contains the following data bearing on the social instincts of that species: (1) The ant attends and colonizes the cotton louse and a mealy bug ('poo-a-pooche') infesting the cane. (2) Adjacent colonies often associate. (3) The ant will feed from the same honey dish with the hive bee and will even clean the latter without arousing any opposition. (4) In attacking stinging ants of their own size, they attempt to injure the tip of the abdomen; but in attacking large ants they rush up, bite a leg or an antenna, and then dart away.

Two papers that have appeared during the past year discuss the behavior of ants towards their guest insects. Newell[3] found two species of mites flourishing in the nests of the Argentine ant; but the ants were entirely indifferent to their welfare, neither removing them nor caring for them in any way. Wheeler[4] discusses the behavior of ants towards three inquilines; *Cremastochilus*, *Microdon* and *Hetærius*. *Cremastochilus* is a persecuted intruder that eventually becomes a tolerated guest. Wheeler thinks it a degenerated true guest, the instincts of which have become so degenerated by years of parasitism that it cannot return to a free life. The larval and pupal *Microdons* are indifferently tolerated guests, but the adult is a persecuted intruder. Towards *Hetærius* the behavior is unique. A study of seven *Hetæri* placed, with *Formica subsericea*, in a Janet nest revealed the following behavior: When an ant passes a *Hetærius*, the beetle waves its forelegs as if to attract attention. The ant stops and feels it with its antennæ. Sometimes she seizes the beetle by the leg and carries it about the nest. At other times she grasps it with her fore feet, holds it in a vertical position and licks its head in a quick, effusive manner. For a while the beetle keeps its head withdrawn into its thorax. Sud-

[1] Comstock, J. H., 'A Note on the Habits of the Wall-bee, *Chalicodomv muraria*,' *Ann. of the Ent. Soc. of Amer.*, Vol. II., 1909, pp. 9–10.

[2] Newell, W., "Notes on the Habits of the Argentine or 'New Orleans' Ant, *Iridomyrmex humilis* Mayr," *Jour. of Econ. Ent.*, Vol. I., 1908, pp. 21–34.

[3] Newell, W., 'Two Interesting Inquilines Occurring in the Nests of the Argentine Ant,' *Jour. of Econ. Ent.*, Vol. I., 1908, pp. 262–265.

[4] Wheeler, W. M., 'Studies on Myrmecophiles,' *Jour. N. Y. Ent. Soc.*, Vol. XVI., 1908, pp. 68–78; 136–143; 202–213.

denly the ant stops licking, protrudes her tongue and regurgitates a drop of food on the face of the beetle. The beetle protrudes its head, opens its mouth, works its jaws and rapidly absorbs the liquid. This alternate licking and feeding behavior may be repeated over and over again. Even when the beetle is feeding on solid food, the ant will often tear it away and feed it in the manner just described.

V. Vestigial Instincts.

That certain animal instincts are purposeless relicts of past habits has been recognized by Darwin, Forel and others. Wheeler's recent comparative study [1] is a valuable contribution to our knowledge of such instincts. Lack of space restricts me to a mere statement of the author's conclusions. (1) "We not only find ants exhibiting vestigial instincts as a species, but a certain caste within the species may show vestiges of instincts whose full exercise is the prerogative of a different caste." (2) "The vestigial instinct action presents itself as a case of racial or phyletic recollection and must, like representations of individual memory, depend on psychological dispositions abiding in latency." (3) "Vestigial instincts obviously represent a part of an animal's endowment, and their manifestation shows that the capacities of even the lower organisms are greater than their ordinary routine behavior might lead us to suppose." The author stresses his belief in the comparative study of instincts.

VI. Recognition and Memory.

Recent researches have furnished additional evidence, if such be needed, that the homing of the hymenoptera is due neither to a homing instinct nor to any form of reflex action, but to memory. Buttel-Reepen [2] states that the homing of the bumble bee, like that of the honey bee, is largely the result of vision and memory. He believes, however, that odors are effective even at a distance. Giltay [3] also claims that the bee has spacial memory and that it returns frequently to a place that it has once visited, even if in the meanwhile one has cut off the flower. He thinks that, for bees, color has great attractive power and that the influence of odors and shapes is insignificant: even honey seems to have less attractive power than color. Turner has

[1] Wheeler, W. M., 'Vestigial Instincts in Insects and Other Animals,' *Amer. Jour. of Psy.*, Vol. XIX., 1908, pp. 1–13.

[2] Buttel-Reepen, 'Zur Psychobiologie der Hummeln,' *Biol. Centralbl.*, Bd. XXVII., S. 579–587; 604–613.

[3] Giltay, E., 'Ueber die Bedeutung der Krone bei den Blüten und über das Farbenunterscheidungsvermögen der Insekten,' *Jahrb. f. wiss. Botanik*, Bd. XLIII., 1907, S. 468–499.

shown that the mud-dauber wasps[1] and the burrowing bees[2] utilize landmarks in finding their way home. In the case of the mud-dauber light plays an important rôle, but it is light used as a landmark. Any pronounced change made in the topography of the vicinity of the nest of the burrowing bee is sure to disturb the insect on its return to the burrow. Under such conditions, the bee usually searches until it finds the burrow. Before departing again for the field, the bee makes a careful examination of the vicinity of the nest. This examination is never made unless some change has been made in the environment of the nest. If the proper alterations are made in the topography of the vicinity of the nest, the bee may be induced, temporarily, to enter a false burrow.

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RECENT LITERATURE ON THE BEHAVIOR OF BIRDS.

The research activity in the field of bird psychology has recently been so great that an extended review cannot be given in a small compass. The titles here cited serve as the basis of the brief outline which follows:

Abelsdorff. 'Einige Bemerkung über den Farbensinn der Tag- und Nacht-vogel.' *Archiv f. Augenheilkunde*, 58, S. 64.

Craig. 'The Expressions of Emotion in the Pigeon. I., The Blond Ring-Dove (*Turtur risorius*).' *Jour. Comp. Neur. and Psych.*, Vol. XIX., No. 1.

Craig. 'The Voices of Pigeons Regarded as a Means of Social Control.' *Amer. Jour. Soc.*, Vol. XIV., No. 1.

Watson. 'The Behavior of Noddy and Sooty Terns.' Publ. 103 of the Carnegie Institution.

Porter. 'Further Study of the English Sparrow and Other Birds.' *Amer. Jour. Psych.*, Vol. XVII.

Katz und Révész. 'Experimentell-Psychologische Untersuchungen mit Hühner.' *Zeit. f. Psych.*, 1909.

Hess. 'Ueber Dunkeladaptation bei Hühnern und Tauben.' *Archiv f. Augenheilkunde*, Bd. 57, S. 298.

Hess. 'Untersuchungen über Lichtsinn und Farbensinn der Tagvogel.' *Ibid.*, 57, S. 317.

Hess. 'Untersuchungen über die Ausdehnung des pupillo-motorisch wirksamen Bezirkes der Netzhaut und über die pupillo-motorischen Aufnahmeorgane.' *Ibid.*, 58, S. 182.

Hess. 'Untersuchungen über das Sehen und über die Pupillen-reaction von Tag- und von Nacht-vögeln.' *Ibid.*, 59, S. 143.

[1] Turner, C. H., 'The Homing of the Mud-Dauber,' *Biol. Bull.*, Vol. XV., 1908, pp. 215–225.

[2] Turner, C. H., 'The Homing of the Burrowing-Bees (Anthophoridæ),' *Biol. Bull.*, Vol. XV., 1908, pp. 247–258.

Craig gives an accurate and detailed account of the various vocal expressions of one species of pigeon. This furnishes part of the raw material to be used in a series of papers dealing with such topics as inheritance, selection, variation, social influence, etc. The paper on the latter topic has been published. The instincts are found to be flexible. The influence of voice on the social activities of nest-building, breeding, the care of the young, etc., is depicted.

Watson studied the noddy and sooty terns in their native habitat on Bird-key. Much of the work was preliminary in character and was concerned with observation of their habits and instincts. Their habits are discussed under the various cycles of activity such as mating, brooding and rearing the young. Visual and auditory data were both probably used in recognition of mates. In the reaction to the nest, visual factors are not exclusively used, a locality or position factor apparently being utilized when the customary visual clues were disturbed. These birds if sent *north* can return from a distance of one thousand miles along an unfamiliar coast although they have never been more than 15 knots distant from the island in that direction. Young birds learn Porter's simple maze but could not traverse it in complete darkness. They could traverse it however if it were faintly illuminated. Rotation of the maze disturbed the reaction.

Porter experimented upon sparrows, cow-birds and pigeons, using the maze and the food-box as problems. Tests on retention of their habits were made: Little was forgotten after 30 days, but there was quite a loss after an interval of one hundred and forty days. They distinguished marked cards and between variously colored cards.

Katz and Révész used, as a problem on the hen, the inhibition of a preference tendency for food. He found that an increasing interval between groups of tests from 15 seconds to one hour gave a corresponding increase of effectiveness. Retention was tested. Form discrimination was present. When conflicting tendencies occurred the older tendency became more effective as time elapsed. Vertical grains were discriminated from horizontal ones. In a row of grains, the bird learned to select every second or every third grain. Beyond this there was failure. No conclusions in favor of a number sense were advanced. Comparisons were made with the results on human memory.

Hess, Abelsdorff, and Katz and Révész experimented on vision. Hess's tests were the most extended. He used both spectral lights and transmitted lights. (1) The commonly accepted hypothesis that dark adaptation is a function of the visual purple is disproved. Adap-

tation is present in doves, the albino turtle dove and the domesticated fowl. Its scope and rapidity is like that in man. These birds possess few rods and only occasional traces of purple. This conclusion seems well established. (2) The blindness due to a sudden strong light is found to have no relation to the presence of visual purple. Hens are not blinded and possess no purple; owls can see by day, they are not blinded and they possess an abundance of purple. (3) Hess proved that such day-birds as the hen, forty-eight hour chicks, doves, turkey, finch, jack-daw, kestrel and hawk possess a shortened spectrum. Food illumined by rays from blue green to the violet was not touched. The spectrum is longer for owls. Dark adaptation increases the limit slightly towards the violet. A decrease of intensity shortens the spectrum still more. The limit of visibility upon the red end is identical to that for man. This shortening of the spectrum is correlated with the presence of colored oil globules on the cones. These are red and orange with day-birds and hence the short waves of light are absorbed. Owls possess yellow and weak yellow-green globules and as a consequence their spectrum is longer than that of the day-birds. The vision of birds is assumed to be similar to that of man wearing red and orange glasses. Such glasses increased the brightness of the red end relative to that of the blue-violet end. These globules are located between the internal and external processes of the cones and hence the external process is the receptive organ for vision and the pupillary reflex. (4) The amount of pupillary contraction for various wave-lengths was tested by Hess. For day-birds yellow gives the maximum of effect. From yellow to violet the effect decreases more rapidly than from yellow to red. The curve is similar for owls with the exception that the yellow-green gives the maximum of effect. The relative effect of the spectral series is thought to be similar to the brightness values of the spectrum as determined by Hering and to the relative effectiveness of the spectral lights upon food selection. These results were confirmed in a general way by Abelsdorff. (5) Hess, Katz, and Révész conclude that the Purkinje phenomenon holds for birds. With normal intensity of the spectrum, birds first chose the food in the yellow. With a colorless spectrum, they first selected that part brightest to the human eye. (6) Both papers conclude that birds possess color vision. Katz and Révész used variously colored grains of the same brightness to the human eye. Discrimination was possible. Such a conclusion is preposterous. Hess secured a selection of food in a spectral red in preference to that in the blue, when the red was much darker than the blue to man. Since the bird

reacted usually to the brighter color, he concludes that in this case they reacted to the red as red. This conclusion is utterly unfounded, for all his facts indicate that the waves from green to violet are intercepted by the oil globules. This end possesses but little stimulating value. The facts can better be interpreted on the assumption that the spectrum does not possess the same brightness value for birds as for man, that the green-violet lights are less bright than the yellow-red. All of the facts can be explained on the assumption of mere brightness discrimination. (7) Katz and Révész adapted birds to colored light and then compared their reaction with their normal reaction. A disturbance was evidenced, but there was no proof that negative after-images resulted from this adaptation. The influence of adaptation to color upon dark adaptation was studied. The darker the color, the quicker the adaptation, was the apparent result.

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RECENT INVESTIGATIONS BEARING UPON THE BEHAVIOR OF MAMMALS.

The various researches upon the visual and auditory reactions of the dog undertaken by Pawlow's method have already been discussed by Professor Yerkes and Doctor Morgulis. The lack of space prevents us from reviewing here, at any length, more than a few of the recent additions to our knowledge of mammalian behavior. The task of presenting in a single number of the Bulletin anything like an adequate picture of the year's research in comparative psychology becomes more and more difficult.

Habit Formation.

Yerkes and Dodson[2] have given a very careful quantitative study of the effect upon the rise of the white-black discrimination habit of using different intensities of the electric shock (the punishment for entering the darker of the two boxes). Dancing mice were the animals used. It was found in general that the relation of the strength of the electrical stimulus to the rapidity of the learning depended upon the difficultness of the habit. When the two boxes differed greatly in brightness, the rapidity of learning increased as the strength of the stimulus increased from the point of the threshold of stimulation to the point of harmful intensity. When the boxes differed only slightly in brightness the

[1] With the assistance of Misses Fernald and Weidensall, Dr. Waugh and Messrs. Adams and Sutherland.

[2] 'The Relation of Strength of Stimulus to Rapidity of Habit Formation,' *Jr. Comp. Neurol. and Psy.*, Vol. XVIII., 1908.

rapidity of learning at first rapidly increased as the stimulus increased, but beyond a certain intensity, which was soon reached, it began to decrease. As the difficultness of the discrimination was still further increased the strength of that stimulus which is most favorable to habit formation approached the threshold.

Audition.

O. Kalischer[1] has materially advanced our knowledge of the auditory sensitivity of the dog. His work is qualitative in character but it paves the way for a more careful quantitive study. He first tested the dogs with an organ containing nine pipes differing from one another in pitch by almost an octave (deren Töne voneinander fast alle um je eine Octave differierten). The dogs were first taught to respond to the food tone by snapping at a piece of meat held in the hand of the experimenter, and to inhibit this reaction when any other tone was sounded. In later experiments the dogs were forced to spring with the fore feet to the top of a chair before the food could be reached. The experimenter covered the meat with the hand if the dog attempted to get the food whenever the Gegentöne were sounded. The dogs quickly learned to discriminate between the Fresston and the Gegentöne. Many dogs after four or five periods of experimentation (total number of trials not given) began to inhibit reaction to tones other than the food tone. It was found that a habit so formed could readily be broken and the animal trained to react to some other food tone. The animals were trained to react to food tones as low as c_1 and as high as c^1. (No statement other than this is given of the dog's range of pitch.) The harmonium, on account of the sustained character of its tones and its small intervals, is well suited to this type of test. On this instrument the discrimination was perfected to the point where the interval was not greater than a half tone. (No more exact statement than this of the qualitative D. L. is given.) A well trained dog can easily discriminate between clangs which contain the Fresston and those which do not. A habit of discrimination once established is held for long periods of time without further exercise in the habit. The work was controlled by destruction of one or both cochlea, production of temporary blindness, etc. The above reactions were proven to be in all probability auditory in character. Some further work in the paper is concerned with the central apparatus in hearing. The light he throws upon the problem is certainly a faint one.

[1] 'Eine neue Hörprüfungsmethode bei Hunden,' *Sitz. d. Kgl. Ak. d. Wiss.*, X., 1907, p. 204 ff.

Tests in our own laboratory made by Dr. Asa Shaefer upon dogs blind from birth, show that Kalischer's contention for phenomenal pitch sensitivity in dogs is well founded. The paper makes somewhat unpleasant reading because of the fact that Kalischer for some reason or other is laboring under the delusion that he is the originator of the Dressurmethode. That it has been in common use in this country since Thorndike's earliest experiments seems to have escaped his notice.

Vision.

Watson's[1] experiments upon the color vision of monkeys is merely preliminary. That the habit of discriminating between the red and green and between the yellow and blue lights (spectral) arose rapidly and was persisted in steadily all through the great changes which were introduced in the brightness cannot be contested. The author is not ready to affirm without further experimentation that the discrimination was made on the basis of hue and not that of intensity.

Samoljoff and Pheophilaktowa[2] present an interesting series of experiments upon the color vision of the dog. The method consisted essentially in training the dog to select a box with a colored circle pasted on top (green No. i of the Zimmermann series) from two other similar boxes having gray discs of the same size on top (grays selected from Nendel's series). The dogs experienced great difficulty whenever the grays were chosen from any of the numbers from 9–16. After much practice the dogs overcame their difficulties and could make the proper selection with a high degree of accuracy. The habit broke down, however, when the color stimulus took the form of circles, triangles and squares, while the grays were left as in the original test (as circles 25 cm. in diameter). The authors are very conservative in their conclusions. We await with a good deal of interest the further results of their work.

Nagel[3] has a short paper in the same volume of the above journal. It merely calls the attention of the above authors to a similar work of his own and Himstedt's, made some years ago, which apparently had been forgotten by the authors just reviewed (deservedly so!). The experiments referred to by Nagel were those made upon a poodle which had been trained to select at command a red ball from a large number of blue balls differing in brightness. In this last communication,

[1] 'Some Experiments Bearing upon the Color Vision of Monkeys,' *Jr. Comp. Neurol. and Psy.*, Vol. XIX., No. 1, April, 1909.

[2] 'Ueber die Farbenwahrnehmung beim Hunde,' *Zentral. f. Physiologie*, 1907, p. 133 ff.

[3] 'Der Farbensinn des Hundes,' *Zentral. f. Physiologie*, 1907, p. 205.

Nagel states that the dog had been still further trained by Himstedt to seek out red, blue or gray at command from a large series of differently colored balls.

None of these tests can escape the commoner criticisms which have been so often urged against such types of experiments.

Books and General Discussions.

The field has been enriched by the appearance of several books and general papers which can be mentioned only by title. Among these we note the following:

Zur Strassen, Otto. *Die neuere Tierpsychologie.* Leipzig u. Berlin, 1908.

Sokolowsky, A. *Beobachtungen über die Psyche der Menschenaffen.* Frankfurt am Main, 1908.

Bohn, Georges. *La Naissance de l'Intelligence.* Paris, 1909.

Edinger, L., und Claparède, Ed. *Ueber Tierpsychologie.* Leipsig, 1909.

Kirkpatrick, E. A. *Genetic Psychology.* Macmillan Co., 1909.

Schäffer, C. *Ueber die Seelenfrage.* Verhand. d. Naturw. Vereins zu Hamburg, 1908, 3. Folge XVI.

J. B. W.

BOOKS RECEIVED FROM JULY 5 TO AUGUST 5.

Archives of Psychology. Ed. by R. S. Woodworth. No. 13. *The Inaccuracy of Movement, with Special Reference to Constant Errors.* H. L. Hollingworth. Pp. 87. No. 14. *A Quantitative Study of Rhythm: The Effect of Variations in Intensity, Rate and Duration.* H. H. Woodrow. Pp. 66. New York, Science Press, 1909.

Bulletin No. 1, Government Hospital for the Insane. Ed. by William A. White. Washington, Gov. Printing Office, 1909. Pp. 106.

NOTES AND NEWS.

The present number of the Bulletin, dealing especially with Comparative Psychology, has been prepared under the editorial care of Professor Watson.

Manuscripts intended for publication in the series of *Psychological Monographs* of this Review should be addressed to Professor James R. Angell, University of Chicago, who takes the place of Professor Judd as editor of the series.